# Isotopic clues (U-series, $^{14}C$, $^{13}C$, $^{18}O$) on growth process and age of Arctic fissure calcretes (endostromatolites) from Northern Canada

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Fissure calcretes could represent early continental forms of life in the Earth's history and are of interest for exploration purposes on other planets. They are observed filling diaclases in permafrosted karsts from Arctic environments and consist of secondary carbonates with layered and/or dendritic sub-millimetric microstructures, suggesting sub-aerial bacterial activity under relatively extreme climatic conditions. We report here on $^{238}U$, $^{234}U$, $^{230}Th$, $^{226}Ra$, $^{14}C$, $^{13}C$ & $^{18}O$ analyses of a few specimens from Bear Cave (Yukon). A first sample yielded inconsistent $^{14}C$- and $^{230}Th$-ages (ranging from bottom to top of the concretion10-4 ka and 260-55 ka, respectively). Higher resolution measurements in a second sample better illustrate trends from the layer immediately attached to the host rock (here Paleozoic limestones) and the outer, columnar surface of the concretion: i) $^{230}Th/^{238}U$ activity ratio decrease from near secular equilibrium values to appr. 0.2; ii) $^{238}U$-concentrations increase from ~ 2 to ~ 6 ppm, and iii) $^{226}Ra/^{230}Th$ activity ratios increase from near secular equilibrium values to 1.2. This pattern suggest a pseudo-Rayleigh fractionation process with redistribution of U-series isotopes from the host-rock into the calcrete growth layers, more or less in function of their relative solubility. Some addition of more soluble elements relating to water fluxes cannot be ruled out. Stable carbon isotopes suggest a similar process with a progressive enrichment in $^{13}C$ (up to +8.5 ‰ vs. VPDB) attributed to kinetic fractionation with freezing of water inducing outgazing of an isotopically light $CO_2$ with precipitation of a $^{13}C$-enriched calcite. The trend for a progressive enrichment in $^{14}C$ suggests partial exchanges with the atmospheric $CO_2$ circulating in bedrock fissures. Thus, if $^{14}C$ and U-series methods cannot be used to set the age of such calcretes, they provide information on their accretion process. In view of the excess $^{226}Ra$ observed throughout most of the concretion, the overall age of the study specimen cannot exceed a few thousand years (i.e., mid- to late-Holocene), but one cannot estimate any precise duration for the growth phase within this interval.

# He-$CO_2$ characteristics of submarine and subaerial fluids of the Costa Rica forearc

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We report He-$CO_2$ isotopic and relative abundance results for groundwater and cold seep fluids from subaerial (Nicoya Peninsula/Pacific Coast) and submarine segments of the Costa Rica (CR) forearc, respectively. Our aim is to assess and characterize shallow outputs from the subducting slab – in terms of chemistry and fluxes - for comparison with deep(er) slab outputs sampled via arc magmatism at the volcanic front.

All samples indicate a strong and variable contribution of mantle-derived He to the CR forearc. Groundwaters on Nicoya and the adjacent coast have $^3He/^4He$ ratios significantly above crustal production values – from 0.45 to $3R_A$ ($R_A$ = air $^3He/^4He$), which equates to a mantle contribution up to ~38 % of the total He. $CO_2/^3He$ ratios span 3 orders of magnitude (0.3-300 x $10^9$) with $\delta^{13}C$ values mostly low (-15 to -20 ‰). The maximum $^3He/^4He$ ratio off-shore is 1.4 $R_A$, at Jaco Scar, the $\delta^{13}C$ values span a much greater range (-11 to -60 ‰) and the fluids show greater super-saturation in $CO_2$, up to 0.34 ccSTP/g$H_2O$. In contrast, arc front volatiles have $^3He/^4He$ ratios between 6-8 $R_A$, a narrow range of $CO_2/^3He$ ratios (~ $10^{10}$) and mostly high $\delta^{13}C$ values (-6 to -3 ‰).

There is a clear contribution of mantle volatiles to both the forearc and arc front. At the forearc, this contribution occurs from the mantle wedge and/or the lithospheric mantle of the subducting plate via the plate interface and upper plate faults. It is dominated, however, by $CO_2$ – partially modified by the effects of methane oxidation - from the shallow slab and/or over-riding plate. Volatiles at the arc front reflect an enhanced mantle contribution superimposed upon a strong slab flux. Significantly, $CO_2$ fluxes at the forearc are extremely low compared to the arc front reflecting effective retention of slab-derived $CO_2$ through the shallow subduction cycle. Recycling of $CO_2$ to the atmosphere is dominated by arc front emissions.